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The Application of Frequency-Conversion Technology in Groundwater Source Heat Pump System Reconstruction

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Abstract: Deep well pump power is relatively ubiquitous in the groundwater heat pump air-conditioning system in some hotels in Hunan, and the heat pump usually meets the change of the load by throttling. Therefore, frequency conversion technology is proposed to be applied in the deep well pump so as to save energy.

Key words: frequency-conversion control, well deep pump, ground-water source heat pump, energy saving

1. INTRODUCTION

Now the energy consumption of the central air-conditioning system takes much share in the buildings. So people begin to attend how to save the air-conditioning energy. For an air-conditioning system, its energy consumption is mostly made up of the unit, the cooling water pump and the chilled water pump, and the type of these equipments is selected in the worst condition in the design. But, the worst condition is only little in a year and the system runs in the partial load in the most time. So the energy consumption of the equipment has a big room to save. In the paper, the hotel requires to reconstruct the system to save more energy. According to operating states of groundwater heat pump air-conditioning system in a hotel in Hunan, the frequency-conversion technology is purposed to be applied in the deep well pump so as to save much energy.

2. INVESTIGATIONS ON RUNNING OF THE SYSTEM

The hotel lies in the Li city in Hunan. The groundwater source heat pump unit is connected in parallel by heat pump unit and heat pump unit . The heated water is transported in the parallel connection by two circulation pumps, whose power is 2.2kW, and the deep well pump is only one and its rated power is 7.5kW, all the water pumps run in the steady-flow. Through testing and investigating the running and the run data of the system, we find, the occupancy ratio of the hotel is relatively poor, and the change of the outdoor temperature is great and so on. As figure 1 shown, the system usually runs in the partial load and sixty percent of the design load is the most. When the water flow is a little, it usually is throttled by the value so as to waste much energy.

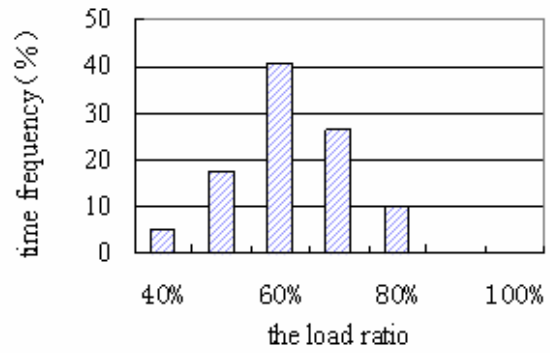

Fig. 1 The load ratio of the system

3. ANALYSIS OF THE EXPERIMENT

3.1 The Influence of the Water Flow on the System COP

3.1.1 The Influence of the Deep Well Water Flow on the System COP

When building loop water flow rate and temperature remain constant and the difference in temperature keeps about 5 , from figure 2, we see that the system COP shows parabola trend line with

the change of the deep well water flow. If the well water flow improves, the transfer coefficient boosts resulting in larger heating capacity. When the well water flow continues to improve in 2.5L/S, the system COP will come to a head. But, the deep well pump power is also increasing so that the system COP reduces gradually. It is obvious that when the system runs in the partial load, the system COP will reduce if the water flow remains constant. It will waste much energy [1].

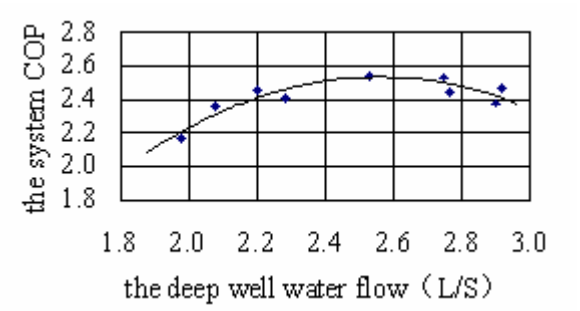

Fig. 2 The relation of the system COP and the deep well water flow

3.1.2 The Influence of the Loop Water Flow on the System COP

As is seen from figure 3, the system COP improves as the loop water flow rising, and the rising trend will be gradually gentler. When the water flow is 3.4L/S, the system COP will be the most. Hereafter the system COP only slightly falls with the improvement of the water flow. Compared with the influence of the deep well water flow on the system COP, the reducing range is very small.

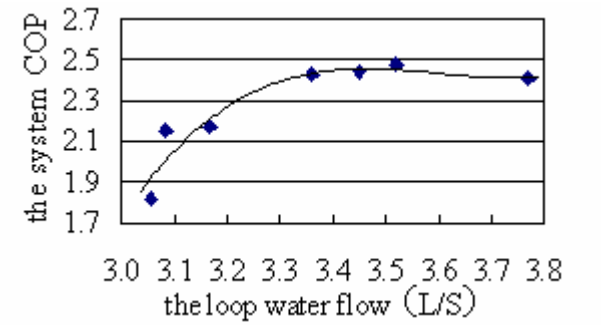

Fig. 3 The relation of the system COP and the loop water flow

Compared with the deep well pump power, the weight of the loop water pump power in the whole air-conditioning system is small. So the system COP can't obviously reduce with the improving of the water flow. Therefore, when the system operates in partial load, if the water flow remains constant and it runs according to the full load, the system COP will be not reduced and it is not also able to save energy.

3.2 Suggestion of Frequency Conversion Technology in the Reconstruction Project

The central air-conditioning system involves the heat pump unit, the deep well pump and the loop pump. Consumption of the electricity is relatively great. The ground source heat pump unit has a function of auto-regulate energy. For the water pump, from the above analysis, we see that the influence of the deep well pump in constant flow on the system COP is greater than the loop pump. And the deep well pump power has a more proportion in the whole system than the loop pump. A combination of factors led to reconstruct the deep well pump in the variable flow.

When the rotating speed of the motor slightly reduces, consumption of the electricity will reduce sharply. So we adopt the method of regulating speed by modulate electrical source frequency. The frequency conversion technology and reasonable self control project are combined, and then the water pump will be controlled by variable flow so as to save energy [2].

4. THE PROJECT OF REGULATING SPEED OF THE DEEP WELL PUMP BY FREQUENCY CONVERSION

For regulating speed and auto control system by altering frequency, according to the difference (arisen by interfering) between the actual value and the given value of adjusted parameter (such as temperature, relative humidity et al.), we control the difference of other parameters by the auto control system (be involved by different parts) so that the parameters fluctuate in a certain range, as is shown in figure 4.

The deep well water temperature remains about 18.5℃ all year round, so we control the well water temperature difference of inlet and outlet by controlling the well backwater temperature. Now the temperature sensor, transducer and the PID loop controller will be composed to be closed loop control

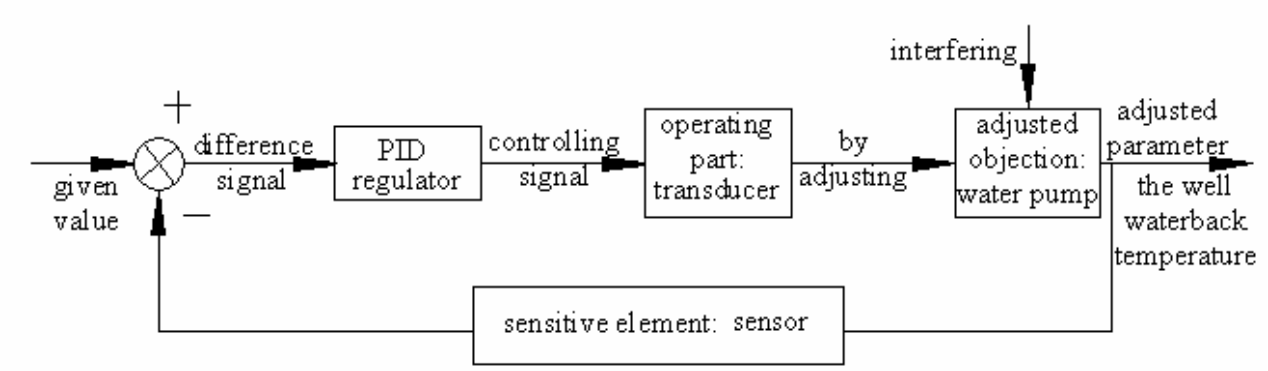

Fig. 4 The pane figure of the automatic regulating system

system. According to the temperature difference index of 5～7℃, the deep well water temperature is controlled in T℃(such as 12℃ in winter, 25℃ in summer) and the rotate speed of the deep well water pump will be changed with the heat load.

Take the case of winter, when the load rises, the deep well backwater temperature will reduce. The temperature sensor feedbacks the temperature signal (4～20mA） to the PID loop controller. The PID loop controller operates by the temperature difference between the given value and the feed backed value, and then input a signal of improving the motor frequency to the transducer so as to increase the rotate speed and flow of pump until the temperature equals the given value. On the contrary, the water pump frequency is decreased to the lower limit given by the instrument, then the transducer stops reducing frequency to meet the request of the unit to the flow so as to protect the unit [3].

5. ENERGY SAVING EFFECT OF THE DEEP WELL PUMP

The rated power *N* of the deep well pump is 7.5KW. During the reconstruction, we select a FUSHI transducer whose model type is FRN7.5G11S-4CX and price is 6410 Yuan. If the other equipment is also added, the gross investment M0 will be 7000 Yuan.

After the system has been reconstructed and has run for one year in the hotel.

Before the system isn't reconstructed, the system doesn't adopt frequency conversion technology, the water pump power consumption all the year round Q_1 is24300 kWh.

After the system adopts frequency conversion technology, the water pump power consumption all the year round Q_2 is15300 kWh

Then the power consumption that the system will economize ΔQ is

$$\Delta Q = Q_1 - Q_2$$
$$= 24300 - 15300$$
$$= 9000 \text{kWh} \qquad (1)$$

Static state reclaim period:

$$n = \frac{M_0}{M_1} = \frac{7000}{9000 * 0.98} = 0.79 \text{ year,}$$

Within

M_0 — the added initial cost after adopting frequency conversion technology, Yuan

M_1 — the economized operating cost every year, the local utility rate is 0.98 Yuan per kWh

Then the initial cost will be reclaimed in nine and a half months.

6. CONCLUSIONS

All in all, according to operating states of groundwater heat pump air-conditioning system in the hotel, the paper presents the reconstruction scheme for frequency conversion control of the deep well pump in the system. The running results show the system has economized much energy, and reclaim period is short. In a word, the reconstruction is feasible.

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